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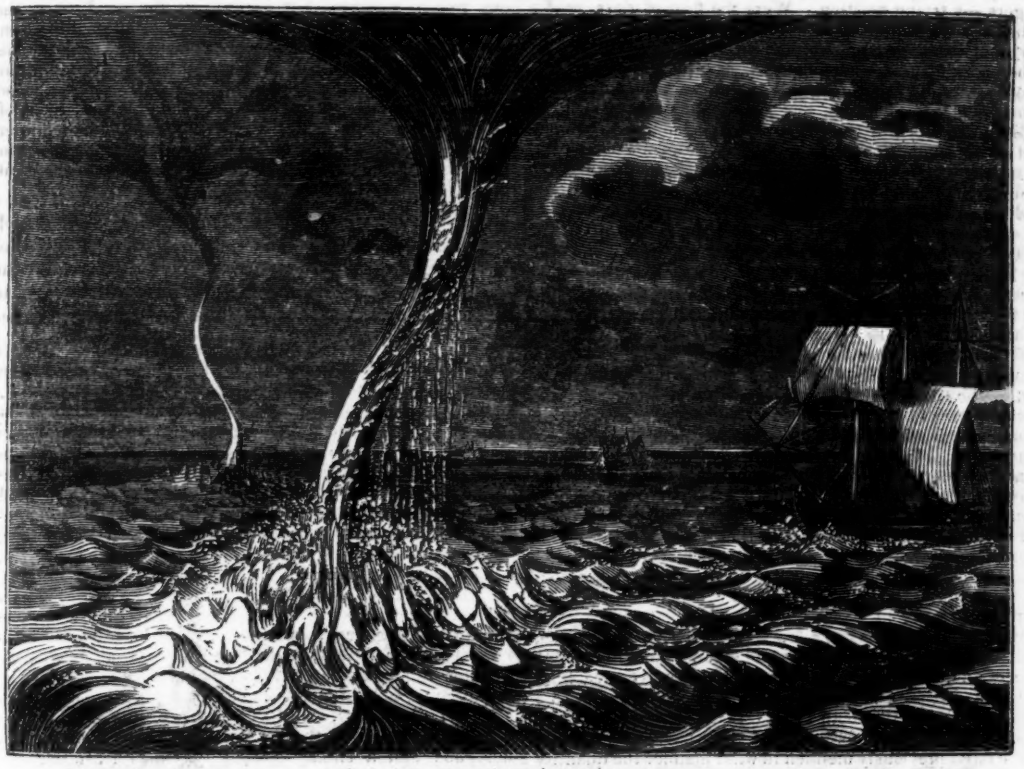
UNDER THE DIRECTION OF THE COMMITTEE OF GENERAL LITERATURE AND EDUCATION APPOINTED BY THE SOCIETY FOR PROMOTING CHRISTIAN KNOWLEDGE.

ON THE WEATHER. No. II.



WATER-SPOUT AT SEA.

RAIN, SNOW, HAIL, SLEET, ETC.

In the first division of our paper on this subject, we explained the constitution of our atmosphere, and the gradual changes which it is constantly undergoing, as regards the relative dryness or moisture of the air. We now proceed to those periodical phenomena caused by the changes alluded to, and which, by their sudden commencement and abrupt cessation, are more calculated to solicit our attention.

Rain.—The immediate cause of the descent of rain from the atmosphere, is the combination of two beds of air possessing unequal temperatures, and unequally charged with vapour, the resulting temperature of the mixed air being below that which is competent to retain the whole quantity of vapour in the gaseous state; some of this must accordingly become condensed, and will fall in the form of rain.

The progress of the phenomenon has been thus stated; "when two currents of atmospheric air of different temperatures, and each charged with vapour up to the point of saturation, are brought into contact, they begin to intermingle by virtue of the diffusive tendencies of the air and vapour, and the immediate result will be the formation of *visible vapour*, that is to say, of a *cloud*. If the currents are continuous and uniform, the clouds soon spread in all directions, so as to occupy the whole horizon, while the additional moisture, incessantly brought by the warmer current, keeps up a constant supply for condensation, and produces a great and continued deposition of moisture in the form of rain. By degrees the currents completely intermingle, and acquire a uniform temperature; condensation then ceases; the clouds are re-dissolved; and the whole face of nature, after being cooled and refreshed by the necessary rain, is again enlivened by sun-shine, and rendered still more agreeable by its contrast with the previous gloom."

Some part of the rain which falls from the atmosphere is supposed to be the result of a chemical action effected by electric agency; a volume of oxygen gas is thereby caused to unite with that definite proportion of hydrogen necessary to form water, and a shower of rain is the result; it is most probable, however, that this action takes place but rarely.

Observation and experiment, as well as *à priori* reasoning, have proved that the former of these causes is adequate to account for all the diversity presented by this phenomenon. The very unequal distribution of water over the earth's surface, the unequal temperature of the air, and the constant currents taking place in it, both horizontally and vertically, occasion the great inequality in the quantity of rain that falls in different countries, and at different seasons. There are, however, difficulties which might present themselves to the reception of this explanation; it might seem, considering the constant fluctuations in the air with respect to both the conditions above alluded to, that rain would be more constantly falling; but it must be understood that there are limits within

which the union of two volumes of air, of unequal warmth and moisture, may not produce that depression of resulting temperature which is necessary for the condensation of the superfluous vapour. Secondly, it might appear surprising that the cause alleged should be capable of accounting for those deluges of rain which visit tropical countries periodically, or even for the sudden and violent rains of temperate climates, since it is only a portion of the vapour of the combined mass of air that is deposited. The answer to this objection is the same as that we formerly gave, when accounting for storms of wind, namely, that it is but an insignificant portion both of surface and quantity, as regards the whole atmosphere of the globe, however overwhelming it appear at the time to such a being as man.

There are some circumstances respecting rain into which it is interesting to inquire:—the extent of country over which rain may fall at one time, and the quantity that falls in different countries at different seasons, as well as the variations of this quantity. Mr. Howard, the celebrated meteorologist, ascertained, in October, 1813, that a rain which broke up an uninterrupted continuance of fine weather, for several weeks, extended over the greatest part of England on one day. On this occasion, a current which set over the Atlantic brought a volume of saturated air in collision with the south-easterly winds which had previously prevailed. It is asserted on the other hand, by the same gentleman, that during the great drought which visited England in August and September, 1815, it rained almost every day in Wales for three weeks of the time. So also in 1816, the central part of Europe was suffering from excessive wet; the whole country, from north to south, through which the Rhine flows, and a surface three times as broad from east to west, was flooded; dykes were broken, bridges blown up, crops washed away, and the vintage ruined by want of sun to ripen the grapes; while for a part of the time, the north was suffering from drought, and prayers were actually being simultaneously offered up at Paris for sun-shine, and at Riga and Dantzic for rain. In general, rain is very partial in its extent, and of short duration; every one must have witnessed the existence of a shower not a quarter of a mile from him, while he has been in unclouded sun-shine.

The average quantity of rain that falls annually, and even in monthly succession, at any one place, is tolerably constant, as might be anticipated from the regular recurrence of atmospheric changes. The absolute quantities that fall at different places vary, from absolute and eternal drought, which prevails in a few spots of the earth's surface, to that which must result from a climate, which, in the 365 days of the year, has not more than sixty-five free from rain. Nevertheless, there exist singular exceptions to this average regularity in both these respects, and we will here record a few for the information of our readers.

We must previously mention in what manner the quantity of rain that falls at any place is expressed; this is by stating what depth the sheet of water would be that would be formed, if it could be equally spread over the surface. The mode by which this is measured we shall explain in a subsequent paper, when treating of meteorological instruments. Thus, if the annual quantity of rain in Britain is stated to be thirty inches, this means that the whole rain that falls in a year, on an average, would cover the surface of the island to that uniform depth, and would amount to about 2,000,000 tons of water per square mile.

In our own country the average quantity of rain for the months of June and July are 2·3 inches*; in 1810, in the latter half of the former, and the first half of the other month, 5·13 inches of rain fell. In 1782 there fell at Kendal, in Westmoreland, 83¼ inches, the average for that place being only 54 for the year.

But the most striking instances of deviations from the average quantity of rain, falling in a limited time, occurred in the year 1827, over many parts of the continent of Europe. M. Arago wrote a brief memoir on this subject in the *Annales de Chimie*, from which we give a few facts on that unimpeachable authority. At Geneva, on the 20th of May, 6·4 inches of rain fell in *three hours*: at Montpellier, 16·7 inches fell in five days, from the 23rd to the 27th of September inclusive; 12·6 inches of that quantity fell at that place in 48 hours only on the 24th and 26th.

* Influenced by our feelings, we frequently imagine that the months of November or February are more wet, because they are more gloomy or cold, than others; but it is a fact, that, on an average, more rain falls in July, and less in February, at London, than in the rest of the year.

The maximum of rain that had ever fallen on a single day at Joyeuse, during 23 years' observation, had been found to be 9·8 inches, which apparently enormous quantity fell on the 9th of August, 1807; yet, on the 9th of October, in the year 1827, in 22 hours only, there fell at that place 31 inches! and in 11 days of that month, 38·4 inches altogether fell at Joyeuse, being double the average quantity that falls at Paris in a whole year. On the coast of Malabar, during fourteen years, the greatest quantity of rain that ever fell in one day, or in 24 hours, was 7·6 inches, not being one-fourth so much as fell at Joyeuse in 22 hours only. The torrent at Joyeuse was the result, as might be expected, of a violent thunder-storm.

With the exception of such anomalies as that we have just recorded, the rains of temperate climates are generally inferior to those which periodically occur in most intertropical countries; and, in order to give an idea of the disproportion, we may state that at Cayenne 151 inches of rain fell in one month only, February. According to Humboldt, the average quantity of rain in different latitudes is as follows; at the equator, 96·0 inches; at 19°, 80 inches; at 45°, 29 inches; at 60°, 17 inches; but the annual average quantity for a few different parts of the globe may be stated as follows:—

Petersburg	16·0	Five Towns of Switzerland	40·0
Paris	22·0	Penzance	44.0
London	22·7	Twenty Places in Lower Valleys of the Alps	58·5
Eight Towns of the South of France	22·6	Great St. Bernard	63·0
Edinburgh	25·4	Vera Cruz	64·0
Six Towns of N. Germany	25·1	Calcutta	81·0
Madeira	31·0	Ceylon	84·0
England	33·3	Adam's Peak	100·0
Mean of 147 Places in Europe	34·7	Malabar Coast	123·5
Rome	39·0	Leogane, St. Domingo	150·6

It is a mortifying confession to make, that our knowledge of the cause of a phenomenon so constantly occurring as rain, is still extremely imperfect; though the explanation we have before stated is undoubtedly correct, as to the general principle, there are many circumstances regarding the formation of rain that are not satisfactorily accounted for by it. We shall here content ourselves with a statement of a few *facts* respecting rain that are interesting, without entering into discussions concerning their causes, or, at most, briefly alluding to the more plausible solutions.

It has been observed, that more rain, on an average, falls on land, *near* the ocean, than on the sea itself; this may be accounted for by supposing the currents to bring the surplus of vapour, formed above the sea, over the land, before it meets with another current by which it may be condensed.

More rain falls in mountainous countries than on extensive plains. Thus, in England the annual average at Kendal is 56 inches, though that for the whole island is only 33; and a similar inequality exists for other districts, not only in Britain but other countries. At Geneva the average rain is 42½ inches, and at Great St. Bernard 63; at Jolmezzo, in Friuli, 82; at Carfagnano, in the Apennines, 92, annually, while that for Europe generally is only 35, and for Paris only 22. There are several causes that may concur to produce this inequality. 1. The partial currents that exist in mountainous districts, caused by the unequal heating of large masses of rocky mountains, one side of which is exposed to the sun's rays, while the other is in shade. 2. The attraction that elevated mountainous ridges present to passing clouds, causing them to accumulate in such localities. 3. The existence of lakes and basins of water in the hollows of mountainous districts, which are sources of constant and abundant evaporation.

The effects of lofty mountain-chains, or high table-lands, in producing the most striking difference between the countries they separate, as regards the quantity and period of the rains in each, is strikingly exemplified in the Indian peninsula. The rainy months at Bombay are from June to October inclusive, while along the opposite Coromandel coast the seasons are exactly the reverse, apparently owing to the central table-land.

In South America the lofty chain of the Andes produces a similar discrepancy; in those parallels, where the chain approaches the Pacific, the boundless plains on the east, within the tropics, are deluged by the periodical rains from November to May, while the narrow strip of land to the west is almost entirely exempted from rain.

But this diversity of climate is shown in a more striking manner, because within a smaller area, in Ceylon; one

side of a lofty mountain, in the district of Doombera, is enveloped in clouds and mists, and deluged by rains, while the other is suffering from an unclouded sun and complete drought. Again, the little town of Cumanacoa, in Colombia, is situated about seven leagues from the port of Cumana, and is elevated about 600 feet above the level of the sea; it has a regular rainy season of seven months' duration, while at Cumana a shower of rain is a rare occurrence. Even in the Sandwich Islands, where no great difference in climate could be expected over such small islands, surrounded by a vast ocean, yet but a small quantity of rain falls on the *western* shores, while showers are frequent on the eastern, and occur almost daily on the mountains.

The modifications on the earth's surface produced by the labours of man, must, in some measure, influence the quantities of rain that falls at different places. The destruction of forests would cause a diminution, and, probably, the conversion of arable into pasture, or the reverse, may even affect the quantity. It appears from observations, that while the quantity of rain that falls at Paris has not varied in 130 years, that at Viviers has been augmenting, and a similar change appears to be taking place at Milan and other places.

When the power of the moon in causing tides was ascertained, it was inferred that the same force must produce still greater undulations in the rarer fluid of the atmosphere; and that the times of comparatively wet or dry weather would coincide with the changes of that luminary. These inferences have not, however, been borne out by observations, either because the connexion between the weight of the air, and its capacity for moisture, is not sufficiently understood, or that the fluctuations are too small to be observable; nevertheless, M. Everest, from repeated reference to meteorological diaries, has come to the conclusion, that more rain falls, on the average, during the few days preceding the new moon than during the rest of the lunar month. But this law varies for different seasons of the year, and during the autumnal months, from August to December, it is just reversed.

M. Schübler, on the contrary, instituted meteorological observations at Munich, Stüttgard, and Augsburg, during upwards of twenty-five years, from which he deduced these proportions. The number of rainy days during the interval from *new* to *full* moon, is to that during the latter half of the lunation, as 1609 : 1457, or, more briefly, as 6 : 5; and that there is a tolerably regular increase in the number of rainy days from the new moon till the full, and a gradual diminution from this till the new moon again.

It would be almost in every one's power to confirm or refute these opposite conclusions by accurate, but easy, observations continued for a sufficient period. We believe that as yet the observations on which the deductions are founded, are not numerous enough to warrant their justness, and that we are far from knowing what connexion there really exists between barometric weight of the atmosphere and the phenomenon of rain.

In the same perpendicular column of the atmosphere, the quantity of rain that falls *increases* as it approaches the earth. This has been accounted for by supposing, that each drop of rain, in descending through warmer strata of air in succession, receives constant accessions of water from the condensation it produces by its own lower temperature, or, in short, that each drop of rain increases in size, much in the same way a snow-ball is increased by rolling in snow.

SNOW.—If a quantity of water, floating in the air in the comminuted form of visible mist or cloud, be suddenly exposed to a great decrease of temperature, under circumstances which prevent the minute particles coalescing into rain-drops, they are congealed, and assume the form of snow.

When examined with a magnifying glass, snow is found to consist of minute, separate, regular crystals of ice, presenting a variety of beautiful forms, though generally consisting of modifications of a hexagon; those most commonly met with are like stars of six rays, each ray being branched or ornamented with ramifications; a great many of these are shown in the engraving at page 88, of the present volume. It is, however, only during the intense cold, and in the tranquil atmosphere of the polar regions, that snow-flakes present such perfect regularity of crystals; and they can but rarely be observed in the temperate regions of the globe, where the inequality, in point of temperature, of the different strata of air through which the snow descends, partly dissolves the flakes, while the agitations they are exposed to by currents, destroy their symmetry. In the polar regions snow, when it falls, is quite dry, and very different in its appearance to that we are accustomed to in our moist climate.

The wind, when it blows over a field of snow, sometimes raises small masses, which become rounded by friction, and increase in size by the accumulation of new snow, till they are too heavy to be blown further. Great numbers of these balls are occasionally seen on extensive plains, and their tracks in the snow, with which these are covered, may be traced for some distance in the direction of the wind.

Snow has been observed occasionally to be distinctly phosphorescent. This was noticed in March, 1813, by some persons on Lochawe, in Argyleshire, when the light was so great as to make the bodies on which the snow fell seem to be on fire; but the light which is given out by snow at night-time, has been observed by every one, though in a less striking degree.

Great benefit is derived from snow, by the protection it affords to vegetation from the effects of severe cold; but for the snow the polar regions would be equally uninhabitable by man or animal, for vegetation would be utterly destroyed. In these inhospitable regions snow also serves the purpose of a material for building, and is employed by the Esquimaux for constructing their winter-huts*.

The fatal effects of a snow-storm, to travellers overtaken by it in mountainous districts, has been frequently and eloquently described†, and even in our country, where every convenience for journeying is afforded by excellent roads, the obstructions occasioned by heavy snow-drifts are occasionally productive of some inconvenience. It however rarely happens that lives are lost from this cause in England, while we enjoy not only the beneficial effects, but the beautiful appearance of a landscape clothed in snow.

> Thick clouds ascend, in whose capacious womb
> A vapoury deluge lies, to snow congealed.
> Heavy they roll their fleecy world along,
> And the sky saddens with the gathered storm.
> Through the hushed air the whitening shower descends,
> At first thin wav'ring, till at last the flakes
> Fall broad, and wide, and fast, dimming the day
> With a continual flow. The cherished fields
> Put on their winter robe of purest white:
> 'Tis brightness all, save where the new snow melts
> Along the mazy current. Low the woods
> Bow their hoar head; and ere the languid sun,
> Faint, from the west, emits his evening ray,
> Earth's universal face, deep hid and chill,
> Is one wide dazzling waste that buries wide
> The works of man.

HAIL consists of rain-drops frozen into ice, by passing through a stratum of air considerably colder than that in which they were formed; but hail is one of those phenomena in the production of which electric agency is immediately concerned, and presents, therefore, many anomalies that cannot be understood by any one, not thoroughly acquainted with the branch of science that treats of that power. The first remarkable circumstance attending hail is, that it occurs commonly in Spring or Summer, and but rarely in the other seasons; the next is the large size that hail-stones attain, much exceeding that of any of the largest rain-drops; a third, that hail-storms rarely occur in the night-time, and are limited in their extent.

But it is not in England that the phenomenon of hail can be studied in all its varieties. Serious as are the injuries occasionally done to our crops, to our green-houses, and sky-lights by hail-storms, yet they are trifling to those experienced frequently on the continent, especially in certain districts; some parts of France, for example, are known by the appellation of the *hail districts*, from the ravages committed on the crops and vines by destructive storms of hail, which, in a few minutes frustrate the labours of months, or even years.

In July, 1788, a considerable portion of France was desolated by a storm of hail and rain; it commenced in the south-west, and travelled in a north-easterly direction in two parallel bands of four and two leagues in breadth, and nearly two hundred in length. The intermediate space, of about five leagues in width, was deluged with rain.

"This tremendous storm was ushered in by a dreadful and almost total darkness, which suddenly overspread the whole country; in a single hour the whole face of nature was so entirely changed, that no person who could have slept dur-

* See *Saturday Magazine*, Vol. III., p. 209.
† Ibid, Vol. IV. p. 96.

ing the tempest, would have believed himself in the same part of the world when he awoke. Instead of the bloom of summer, and the rich prospects of autumn, which were just before spread over the face of that fertile and beautiful country, it now presented the dreary aspect of winter. The soil was changed into a morass, the standing corn beaten into a quagmire, the vines broken to pieces, their branches bruised, and fruit-trees of every kind demolished. The hail lay in heaps, unmelted, like piles of broken ice. Even robust forest-trees were incapable of withstanding the fury of the tempest,—a large wood of chestnuts, in particular, was so much damaged, that it presented little more than bare and naked trunks; the vines were so battered, that four years elapsed before they were again productive. Of the sixty-six parishes of one district, Pontoise forty-three were entirely desolated, and of the rest, some lost two-thirds, and others, half their harvest." M. Arago has calculated that the damage done in 1039 parishes amounted to 24,962,000 francs, or nearly £1,000,000 sterling.

This remarkable storm moved in its course at the nearly uniform rate of sixteen and a half leagues per hour, and that of the two bands was equal. The western band commenced hailing at Touraine, near Loches, at half-past six in the morning, and at Flushing, in Brabant, at half-past one; the eastern reached Utrecht at half-past two. The average duration of the hail at the different places it visited, was not more than seven or eight minutes.

The sudden depression of temperature necessary for the formation of hail, can only be accounted for by electric agency, and, accordingly, this is always manifested in a greater or less degree. Hail frequently falls during thunder-storms, and even when the electric fluid is not perceived, the contrary currents, the rapid motions of the clouds, and other circumstances, indicate its presence. An attempt has consequently been made in Switzerland, and those parts of France especially liable to devastation, to guard against the effects of hail, by erecting electric-conductors of wire, but the attempt has not proved as effectual as was expected.

Rain generally accompanies hail, the storm commencing with the former, which is suddenly converted into hail, or the reverse. Heavy clouds are observed coming up with a *south-east* wind and discharging torrents of rain; another mass brought by a *westerly* current, meets the former with great violence, and thunder results; the rain ceases and becomes hail, small at first, but rapidly increasing to a large size. Analogous appearances were observed on the 4th of June, 1814, at a place in North America; a dark cloud appeared in the south-west, while some light clouds advanced from the north-east to meet them; the united vapours seemed to rise to an extraordinary height, and hail fell in masses from a foot to fifteen inches in circumference, which was succeeded by heavy rain. Such are the usual appearances presented by hail-storms; the most singular and interesting variations in them arising from the size of the *stones*, as they are called, which vary from that of fine sand, to weighing one or several ounces in weight.

A disastrous hail-storm occurred in the Orkney Islands, on the 24th of July, 1818, which was limited to a band rather more than a mile in breadth, and extended in a direction from NNE. to SSW., from North Ronaldsay to the mainland. Out of this belt the storm was unfelt, whilst within its effects were terrible. Many geese of a large flock feeding on a common, were killed on the spot, and the rest were so injured that they pined and died shortly afterwards; great numbers of starlings, buntings, and other small birds were found killed over the space, and rock-pigeons, crows, guillemots, and ducks, were washed on shore that had been killed at sea by the hail; a boy received so severe a blow on the back of his neck, that he was not only stupified at the time, but some months elapsed before he recovered the effects. Some of the hail-stones that fell on this occasion weighed nearly eight ounces the average weight was four or five*.

Hail presents great varieties of form at different times, though the *stones* which fall in one storm, or at one place, are tolerably uniform in figure; in such circumstances, those that reach the surface of the valleys are larger than those that fall on the elevated hills or mountains; it has been hence supposed that each stone in descending is increased in size by the deposition on it of new layers of moisture that freeze on the previously-formed mass. M. Humboldt observed hail-stones in the Andes, half an inch in diameter, so decidedly formed of concentric layers of ice, that they might be separated by a blow with a hammer A change of wind or of temperature seems to have very immediate effects in altering the form of hail. M. Adanson observed, on the 7th of July, 1769, during a hail-storm, that the stones which first fell were of a six-sided pyramidal form, but on a change of wind taking place to the north-east, the hail-stones took the shape of a lens, or three-sided figure, and were so regular in their density and clearness, that they would magnify objects without distorting them.

Some fell at Bonn, in May, 1822, which were from an inch to an inch and a half in diameter, of a flattened globular form, and consisted of a white opaque nucleus, surrounded by concentric layers, increasing in transparency to the outside. Occasionally, the centre of the hail-stone is of the consistence of snow, while the exterior is perfect ice, and generally the ice of hail-stones is so compact, hard, and elastic, that they will rebound from stone pavements without breaking, in some instances, to the height of several yards. Sometimes the hail, instead of being of a rounded, or regular, figure, appears like fragments of an extended plate of ice which has been broken in its fall. But the most remarkable circumstance concerning hail was the occurrence of nuclei of pyrites in the hail-stones, in a crystalline form, these fell at Sterlitamark, and were examined by a Berlin professor.

The concentric structure of hail-stones has been cited in favour of an hypothesis concerning their formation, offered by the celebrated Volta; namely, that they remain suspended in the air for long periods, oscillating between clouds differently charged with electricity. During this time they receive increase of moisture, till their weight overcomes the electric attraction; but the other points of Volta's theory were found incompatible with observation and analogy, and it is now generally abandoned, though by no means disproved.

It thus appears that dew, hoar-frost, rain, snow, and hail, are only modifications of the same phenomenon—the condensation of vapour held in solution by the air, produced by a reduction of temperature; and as this change may, from different causes, be very sudden, the same water falling from the air may assume the forms of rain, snow, and hail, or, as it is termed, *sleet;* a word that immediately excites very disagreeable associations and reminiscences of traversing interminable open commons, in a south-east or easterly wind, with a fierce driving sleet in our faces, with a light dress, no cloak, no umbrella, and less immediate prospect of getting to shelter.

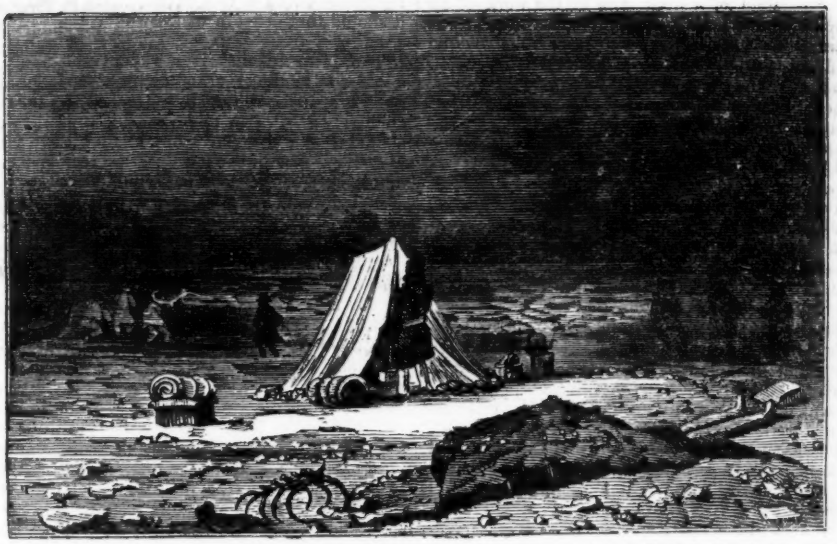
GENERAL OBSERVATIONS ON RADIATION, AND THE CONSEQUENT CONDENSATION OF VAPOUR.

When describing dew and hoar-frost in the preceding Supplement, we stated that we should defer till now some general observations on the various states of frozen water called hoar, snow, hail, and ice, which present some of the most curious and beautiful phenomena connected with our subject.

It is when a reduction of temperature by radiation causes the deposited dew to freeze into hoar-frost, that this interesting subject can be best studied; every one has admired the appearance of hoar-frost, but few are aware that the distribution of it on every exposed object is governed by the most regular laws. Whenever one part of the surface is screened from a free exposure to the sky, that part will have less dew deposited on it, because its temperature will not be so much lowered as that of the rest of the surface the spreading branches of a tree will prevent the grass beneath from being dewed, and hence, while the open field is of the purest white with hoar-frost, under the tree it will be still green. The same cause, however, will produce the same effects by much smaller bodies than a tree: the intervals of the horizontal rails between the upright ones of a wooden fence, will be more thickly covered with rime than those portions which are partially screened by the upright rails, and the lowermost rail, or parts of rails, will, for the same reason, be freer from hoar than the upper.

It has been mentioned, that different surfaces possess unequal radiating powers, and will hence become of different temperatures,—that which is coldest will condense and freeze the dew into the largest crystals and more copiously: and even printed letters will be sharply marked out by crystals of a different size and form from those deposited on the plain part of the paper. This simple law will explain

* Hail-stones sometimes fall with a velocity of seventy feet per second, or about fifty miles per hour; the *momentum* of a large-sized hail-stone with such a velocity, may be easily believed to be capable of effecting destruction even among trees.



FOG, WITH APPROACHING SNOW-STORM, IN THE ARCTIC REGIONS. (*From Captain Back's Narrative.*)

all the varieties, in these respects, presented by bodies under such circumstances, and the decided effect in retarding radiation, produced by apparently slight and inadequate shelter, is shown in the case of plants covered over at night by a garden-mat, or even by a thin muslin cloth. It is inconceivable what great benefits may be derived from a tolerable acquaintance with the phenomena of heat, radiation, &c., and how many interesting facts may be accounted for; the same quantity of material will form a much warmer clothing when made into a loose cloak, which does not touch the body, than if made into a tight dress, sitting close to the person, provided the material be a good conductor, and a good radiator of heat; but if it be neither, and consequently better adapted for the purpose of clothing, it may afford more protection from cold when closely investing the body, than as a loose cloak.

There are different ways in which dew may be frozen on bodies;—the whole quantity of water may be deposited before the temperature is sufficiently reduced to freeze it; in this case, when the latter effect has been produced, the dew will be converted into solid ice-drops; but this is not a common occurrence, though it may be observed occasionally on grass, &c., in autumnal mornings. The crystallization of dew, when it takes place gradually, as the moisture is deposited, varies according to the form or surface of the body; on sharp edges, and on fibrous surfaces, the frozen moisture is in the form of minute sharp icicles, or *spiculæ;* these stand out from the edge at equal angles to the adjacent faces,—and this is the commonest form and arrangement; for it will be observed that more dew is deposited on the edges of bodies than on their flat surfaces. The separate spiculæ are clear and transparent as ice, but their minuteness and intricate texture cause them to refract and reflect light, so as to make them appear white like snow.

Heat is radiated from the surface of water as from any other body, and when the temperature is reduced to 32°, ice forms. But, by a beautiful and benevolent arrangement, water attains its maximum of density at a higher temperature (39½°), than that at which it freezes; till, therefore, the whole body of the water be cooled down to the temperature of 39½°, no part can begin to freeze, for the upper stratum, when it becomes denser than those below, subsides to the bottom, and is replaced by a fresh portion, which rises by its specific levity to the surface, and undergoes the same diminution of heat. When the whole mass is thus cooled down, no further motion can take place among its strata from this cause, and the surface now radiates off more heat till its temperature falls to 32°; but, since in consequence, it becomes specifically lighter than the water beneath, the frozen part cannot sink, and hence the bottom of a lake, river, or pond, remains liquid, because it cannot be cooled down sufficiently to become ice.

If this provision had not been made, and if ice had formed at the bottom as well as at the surface of water, it would take an immense time to thaw again; for the upper portion, receiving the solar heat, would have melted, but the heat could not have descended, water being a bad conductor, and all the ice beneath would remain solid. Animal and vegetable life would, by such an arrangement, have been checked, if not finally destroyed.

The formation of ice is prevented by anything that retards radiation from the surface of the water, provided the absolute temperature of the air be not below the freezing-point by several degrees; but if the temperature of the air be only a degree or two above the freezing-point, then a vessel of water exposed to a clear sky will freeze on the surface, or at so much of the surface as may be exposed; and effects will be produced by apparently inadequate causes, as striking as those we have mentioned regarding the formation of dew. If a string be stretched across, and just above, water in an open vessel, it will prevent the formation of ice beneath it, while the rest of the water will freeze at its surface.

When the surface of water begins to freeze, crystallization commences by the formation of spiculæ, like those of frozen dew; but when congelation goes on rapidly, all trace of crystalline forms are lost.

THUNDER-STORM, HURRICANE, TORNADO, TYPHOON, ETC.

THOUGH electric agency is more or less concerned in *every* phenomenon of the material world, and therefore in all those of meteorology which we have hitherto described; yet in them its activity is not so great as to manifest itself directly to our senses. That of most common occurrence, and observed in every part of the globe, though most frequent in warmer latitudes, is the *thunder-storm.*

It would be a difficult question to solve why this of all others should excite the greatest interest in ordinary minds, an interest always connected with a considerable degree of apprehension and fear, producing a sensation of awe, that has caused the occurrence of a thunder-storm to be regarded as a more immediate manifestation of Divine power than almost all other material phenomena. It may not be useless to remind some of our readers, that this is an error productive of worse than mere personal anxiety. In the first place, the mind rightly trained ought to see the Divine agency in *every* event, physical and moral. The thunder-storm which rives an oak of a thousand years' growth, topples down a church or a castle, and deprives a human being of life in a second, is not a whit more indicative of His presence than the formation of an icicle pendent from a cottage roof. The philosopher regards the lightning and hears the thunder, with perfect *apparent* indifference, not, as is uncharitably said, because he is a presumptuous sceptic, but because he views it only as a more energetic action of a natural agent, ceaselessly at work around him; *his* awe, *his* admiration, are excited every instant, now by a minute crystal, now by the actions of a microscopic animal, now by the texture of a leaf, now by the form of a cloud,

now by the articulation of a limb, now by the work of an artist, and he does not, from vanity and cowardice, attach more importance to that occurrence by which he *may* be injured, than to those by which he *is* constantly instructed and preserved.

The fact is, that if we judge of the danger resulting from any action, by comparing the number of times the action takes place with the number of accidents caused by it, we shall find that thunder-storms are less prejudicial to us than many other actions perpetually going on; for it should be distinctly remembered, that the apprehension felt, and our natural love of the marvellous, induce a considerable exaggeration, both in the number, and extent, of accidents produced by electric agency.

There are few material phenomena by which we are occasionally injured, against which we can take such effectual precautions as against lightning; most others, besides their own immediate action, necessarily excite changes by which the chance of danger to ourselves is increased; but as we can generally foresee the approach of a thunder-storm, so by attending to the simplest rules we can avoid its effects; and if it produce no immediate mischief, which it seldom does, it in no way acts in a manner to produce subsequent evils. A tempest of wind may blow a house or a tree down on our heads, and if it do not, it may so far shake them that they may subsequently fall when we least expect it. A steam-boiler may be endangered, the safety-valve may act tardily, and our apprehension be removed; but the vessel, by the strain, has been weakened, and may burst by a less severe trial next time it is used, when we are not prepared for it. There is no mechanical action of an analogous kind produced by lightning, its beneficial effects are unalloyed; it does not lay prostrate our harvests nor overturn our houses, nor cause rivers to overflow, nor induce infectious diseases; it purifies the atmosphere and imparts new vigour to animal and vegetable life, in some mysterious mode, of which we are, and ever shall be, utterly ignorant, but which we can appreciate by the result. Instead, therefore, of regarding a thunder-storm as a visitation and as a manifestation of Divine wrath, we ought, as rational and grateful creatures, to hail it as a blessing, and rejoice in its occurrence.

The immediate cause of a thunder-storm, is the relative unequal accumulation of electric fluid in two masses of clouds, or in the clouds and the earth beneath; when these differently-charged bodies approach sufficiently near, the equilibrium is restored by the transmission of a part of the fluid from the supercharged one. If some good conducting substance form a communication between the two, the balance is restored silently, but the air being a bad conductor, the electric fluid manifests itself in its passage through it in the form of lightning. The thunder is only the result of the concussion produced by the violent rushing together of the bodies of air separated by the passing fluid; it bears the same relation to the lightning that the report of a gun does to the ball, and is equally innocent. The *rolling* of the thunder is the effect of reverberation from different clouds, or between the clouds and the earth.

The time that elapses between the flash of lightning and the peal of thunder, is an accurate indication of the situation of the storm; the former is always seen at the instant of the discharge, but sound takes some time to travel. If therefore more than a quarter of a minute passes before we hear the thunder, we may be certain that the storm is far enough away to render us perfectly secure. If, on the other extreme, the two are nearly simultaneous, we may anticipate the *possibility* of mischief, and should avoid trees or high buildings, unless they are provided with conductors. But as thunder-storms are always accompanied with heavy rain, and we naturally desire shelter, we should seek it in some low building, *not* isolated, on the lee side of a hedge, provided it have no tall tree near, or best of all in a hole in a rock or bank; and if, unluckily, the storm overtake us in an absolutely naked plain, offering no shelter of any kind, we must sit, or lie, down on the ground, and wait till it pass over. But on such a plain, a man, even by standing, becomes an attraction for the fluid, and if the storm be over his head, he may very possibly, and even probably, be killed. But such a combination of circumstances happens but rarely; animals in fields or on commons seek the shelter of a tree, and are frequently killed in consequence. It may be further mentioned, that it is only a single tree or a lofty building we should avoid; in a wood we are likely to be safe, for if the lightning strike a tree at all, there is but a small chance it should that beneath which we have placed ourselves.

The HURRICANE* is a violent storm of wind, which appears to be the result of direct electric agency; properly speaking, it is confined to tropical latitudes, though by analogy we so term any very high wind. The essential character of a true hurricane is, that it is a violent rotatory motion excited in the air over a great space, and that it moves progressively. But little is known of the true cause of this rotation, and we could not briefly explain in this paper that little; we shall simply state what has been observed regarding these storms.

A hurricane often acts at once over a vast extent of surface, sometimes as much, or more, as five hundred miles. In the West Indies the storms generally advance from the south-east towards the north-west, till they reach the parallel of 30°, when the course changes to the north-eastward and finally to the east. They advance in this course at the rate of from twelve to thirty miles an hour, and the total length passed over is seldom accurately known, apparently because they diminish in violence, and extend in their influence, till they lose their proper characteristics. One hurricane of August, 1830, was afterwards traced in its daily progress from near the Carribee islands to the coast of Florida, the Carolinas, and thence to the banks of Newfoundland, a distance of more than three thousand miles, which was passed over in about six days; its most violent duration at the different places on its route was about twelve hours, but in many its whole duration was four-and-twenty.

Another which occurred in the same month was traced for near twenty-five hundred miles; and a third, in August, 1831, which desolated Barbadoes on the 10th, arrived at New Orleans on the 16th, after passing over twenty-three hundred miles.

The direction of the wind at any place over the greater portion of the track, is found to be different to that of the progressive course of the storm; and the strength of the wind far exceeds that which would be occasioned by the rate of its progress, which would not be productive of any mischief. It appears from observation, that the air whirls round a vertical, or somewhat inclined, axis, with a velocity of eighty to a hundred miles per hour and upwards, this axis of rotation being carried forward in the course above mentioned.

The TYPHOON, or *Taufung*, of the Indian Ocean, is similar to the hurricane of the west in all respects.

When the rotatory motion of the air is of comparatively small diameter, it is attended with effects which give it a distinct character The gyration appears, however, to be only an effect which always accompanies the displacement of a fluid. The principal part of the phenomenon consists in a violent upward current of air, excited by the sudden rarefaction of some part of the superincumbent strata. When this action happens at land, it is termed a whirlwind, and it is often productive of the most extensive and fatal devastations; when it occurs at sea, or over a lake, it is called a *water-spout.*

The WATER-SPOUT is thus described by those who have witnessed it. From a dense cloud a cone descends in the form of a trumpet, with the small end downwards; at the same time, the surface of the sea beneath is agitated and whirled round,—the water is converted into vapour, and ascends with a spiral motion, till a junction is effected with the cone proceeding from the cloud; frequently, however, they disperse before the union takes place. Both columns diminish towards their point of contact, where they are not above three or four feet in diameter. In the middle of the cone forming the water-spout there is a white, transparent, tube, which becomes less distinct on approaching it, and it is then discovered to be a vacant space, in which none of the small particles of water ascend; in this, as well as around the outer edges of the water-spout, large drops of rain precipitate themselves. In calm weather, water-spouts generally preserve the perpendicular in their motion, but when acted on by winds, they move on obliquely. Sometimes they disperse suddenly, at others they pass rapidly along the surface of the sea, and continue a quarter of an hour or more before they disappear.

* We have abridged this account of the hurricane from Mr. Redfield's paper, in Blunt's American Coast-pilot.

Navigators have always, and very naturally, entertained great apprehensions of these meteors, and therefore they are seldom approached near enough to enable accurate observations on them to be made. It is probable, however, that in most cases they would not be productive of any serious injury to a vessel of any size. When they appear to be approaching, it is usual to fire one of the ship's guns at them, which, by the concussion of the air, frequently disperses them. But as the water-spout is only moved in space by the prevailing wind, which is equally acting on the ship, they are usually suffered to pass a-head or a-stern by a simple manœuvre; or they disperse before they are near enough to excite any other emotion than curiosity and admiration.

WHIRLWINDS at land have been only observed in the day-time, and in the summer-season, in our climates, and they seldom visit our island. In France, however, they have been frequently observed, and their appearances and effects accurately recorded. There is, of course, a great uniformity in their action, and the following account of one which occurred on the 26th of August, 1823, in the neighbourhood of Dreux and Mantes, may be taken as a fair specimen of their effects when violent.

The morning had been very sultry: at three in the afternoon, near to the village of Boncourt, in the canton of Anet, a dense black cloud was observed stretching from the south-west towards the north-east, and followed by another not so thick, and of a lurid yellowish tinge. The thunder rolled incessantly—a violent shower of hail fell at Anet, for three or four minutes, which was converted into rain equally impetuous, and lasting for about the same time. A whirlwind had formed in a little valley beneath the hamlet of La Ronce, and extended from the earth to the first cloud; it destroyed fifty-three habitations at Marchefroid in less than a minute, and the only notice of its approach was the fall of hail which preceded it but a few seconds. A child of three years of age, who was in a court with its mother, was killed on the spot,—a deep perforation in its neck was the only wound subsequently discovered.

A wagon loaded with grain, and drawn by three horses, was lifted off its wheels and thrown on the roof of a house, which was crushed in by the weight. The grain disappeared entirely, but the horses did not receive any serious injury; nor did three others who were drawing a plough in a neighbouring field, and yet the implement was carried entirely away. Whole roofs of houses were swept off,—some in the same, and some in the contrary direction to that in which the whirlwind moved. Trees were torn up, and their roots, trunks, and branches transported from sixty to a hundred yards' distance; some which were growing in a valley were broken off at from four to twenty feet from the ground. Four substantial stone walls of a garden were thrown down, each outwards from the area they enclosed, and the derangement of the stones was so regular that they subsequently appeared as if placed in order on the ground ready for the masons.

This meteor passed over a line of five leagues in length, and the average breadth of its course was from forty to fifty yards; within this area, the destruction it caused was fearful: as soon as it was passed, the sun re-appeared, and the temperature was not lowered by the event.

On the 26th of August, 1826, another of these visitations spread dismay in the *arrondissement* of Carcassonne. The wind was in the south, and the heat had been intolerable all the morning; at noon, the clouds gathered in the west, and a violent wind arose; a black and dense cloud appeared hovering over a piece of ground about a hundred yards from the Chateau de la Cannette; the clouds in one direction were observed to meet with great impetuosity and to descend towards the earth as if attracted by it. The thunder rolled on all sides, and a dull rumbling was also distinguished; domestic animals fled in terror, as they are wont to do at the approach of any convulsion of Nature. On a sudden, a frightful cracking was heard to the west, the air rushed tumultuously and with great velocity towards the cloud over the field, the concussion was manifested by a loud report, and the appearance of an enormous column of fire*, which, sweeping along the ground, overturned and destroyed everything in its course. A young man, who was in its route, was whirled round, carried up into the air, and dashed against a rock, by which his skull was fractured; fourteen full-grown sheep were raised up in the same way, and fell senseless. This column of air and fire (?) overthrew walls, removed enormous rocks, and tore up the largest trees; it penetrated into the Chateau by two gates, tearing out and throwing down the masonry and woodwork. It made its way into a saloon, forced a passage through the ceiling into the second story above, and, escaping by the roof, made a complete ruin of all three apartments, with a formidable noise. Two ladies who were in the saloon escaped death, being sheltered by an enormous beam from the falling rubbish. A whirlwind also penetrated the window over the kitchen, threw down a partition, tore up the flooring, broke the furniture in pieces, overset the beds, and even burst open the cupboards, but (very courteously) did not derange the contents! It forced its way through a thick wall, scattering the materials to a great distance, and finally, broke through the roof of the chateau. The same wind also tore up and carried away an enormous oak, five feet in circumference, crushed two small dwellings, carried away some wagons, and, precipitating itself into a ravine, rooted up several large walnut-trees growing in it, devastated the vines, and, ploughing the earth into deep furrows, it finally disappeared in the direction of Fournas, being succeeded by a torrent of rain, which, lasting for a short time, the sky cleared, the weather became calm, and the wind changed to the east.

The wonderful showers of frogs and fishes which are said to occur occasionally †, may be accounted for by supposing a whirlwind to pass over a small lake or pond, the waters of which, with the small animals living in them, it raises and carries to a distance, till, the cause ceasing, the fishes and reptiles fall to the earth again.

There is one circumstance to which we would call the reader's attention; that is, that these whirlwinds only appear in the day-time, and at those seasons at which hail prevails, and that this last-named meteor, as we have mentioned, frequently follows the whirlwind. This would seem to indicate a connexion of cause, and it is probable that in our country hail-storms, which are always accompanied by sudden gusts of wind, may often be the manifestation of the presence of a whirlwind, though too slight to cause damage sufficient to attract attention. Every attentive person must have remarked, at certain seasons, the dust of a road suddenly raised in little vortices; and a precisely similar appearance was observed in France, in a field, to such an extent as to leave no doubt in the observer's mind that he was contemplating, on a miniature scale, what might, on a greater, have caused destruction.

LUMINOUS METEORS.

THERE are a variety of phenomena which take place in the atmosphere, arising from the modifications which light undergoes in its passage through it; and they constitute some of the most pleasing connected with our subject. It may be necessary to remind the reader, that a ray‡ of light is bent out of its straight course in passing obliquely from one medium into another of a different density; and that a ray, when it undergoes this change of direction, is separated into different component rays, each exciting in our visual organs the idea of a different colour. Of these there are three principal ones, red, blue, and yellow, which, by partially combining, produce the intermediate tints of the spectrum.

An object conveys the impression to our mind of being coloured, in consequence of its absorbing some of the component rays, and only reflecting or refracting those to our eyes which are calculated to excite the idea of the colour in question.

THE HALO is a simple luminous ring, or circle, surrounding the sun, or more commonly the moon, of different widths, and at different angular distances. It is produced by the interposition of a mass of vapour, or light cloud, generally frozen, between the luminary and the spectator.

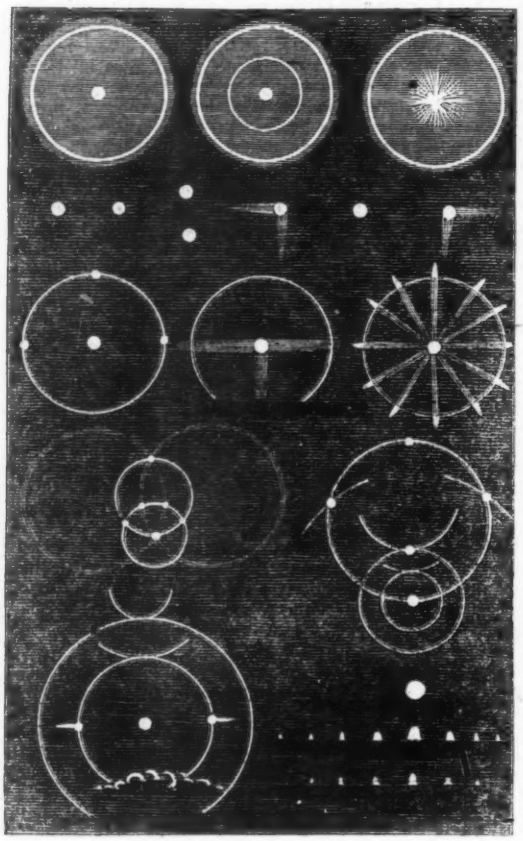
* There is certainly some gross exaggeration here, at least, if not in the whole account; yet it is taken from a French scientific work of high authority.—*Diction. des Sciences Nat.*

† There is no satisfactorily authentic account of such showers; like many other wonders, their occurrence only rests on the evidence of illiterate persons, who are naturally prone to exaggeration.

‡ It is as well to continue the use of this term, though it is not exact or correct; it expresses something *positive*, whereas, what we mean by a ray is only the line in which a series of undulations is propagated through the ethereal medium. It is difficult to modify properly that language which was framed when light was supposed to be a material body itself in motion, instead of being the consequence only of motions excited in an all pervading medium.

The parallel rays from the luminary, in approaching the earth, are refracted by the drops of vapour through which they pass, and arriving at the eye in a direction different from that in which they originally were moving, produce an impression of light in a circle distinct from the sun or moon itself*. When the halo is a lunar one, the ring is seldom coloured, owing to the faintness of lunar light, which, being reflected, does not contain all the prismatic elementary rays as *direct* solar light does.

The angular distance of the ring from the moon depends on the relative distance of the mass of cloud from the spectator. Sometimes two rings, or a double halo, is seen; as it is probable that the mass of vapour that originates a halo is frozen, or crystallized, the different refraction of the rays passing through solids, bounded by planes not parallel, and the reflection that takes place within the body, will produce more than one ring of light.



When the halo is only a circular disk surrounding the sun or moon, and touching it, it is called a *corona;* but this is only a modification of the halo, and frequently accompanies it. A corona is always seen when a light cloud passes before the sun or moon.

Halos are occasionally produced by mists or vapours resting on the earth, as has been proved by their alternate appearance and disappearance, when the spectator has been crossing fields, over which vapours were resting or not; and in the case of a combined halo and corona, it is probable that the latter is often caused by vapour nearer the earth than that which occasions the halo.

In warm climates, and in purer atmospheres, lunar halos are often prismatic, and small ones have been seen round the planet Venus. The three upper figures of the subjoined print represent lunar halos and coronæ.

* Cover a piece of clean glass evenly over with a strong solution of alum, and leave the moisture to evaporate slowly, the alum will crystallize on the glass in an even white coating. If a candle be looked at through this glass, portions of radiating lines will be seen, forming concentric luminous rings round the light, and will explain the origin and nature of halos, &c.; but as the crystals of alum are not perfect, the rings will not be so distinct as those of a real halo.

Parhelia are optical phenomena, one or more images of the real sun appearing simultaneously with it, and at the same elevation; these images are united by a horizontal circle of white light. Sometimes one false sun only is seen on one side of the true one, and having a cloud for a back-ground; occasionally a second image, fainter than the first, will be seen on the other side. The parhelia, or images, are frequently tinted with prismatic colours, and an arch of light proceeds from them, the circle not being completed; and when it is, still the images are brighter and more tinted than the rest of the circumference. Secondary circles and arcs of circles accompany the principal halo, and the images are repeated four, five, or even seven times, but this complication is very rare; figures of a few are shown in the engraving.

Captain Parry, who had the opportunity of observing great numbers of parhelia in the arctic regions, found, from observation, that the medium which caused them, was nearer the spectator than the appearance of the images would at first lead one to suppose. The images are most brilliant, and most frequently occur when the sun has little altitude†, and hence occur chiefly in winter. They appear with the greatest brilliancy soon after sunrise, diminish in intensity as the sun ascends higher, and occasionally reappear when the sun approaches the horizon at setting, having been extremely faint, though still visible during the day. These conditions lead us to conclude, that they, like rainbows, halos, &c., are phenomena of refraction, caused by floating, frozen vapour in the atmosphere, the primary simple appearance being, in high northern latitudes, modified by terrestrial refraction and reflection from fields of snow or ice.

A splendid example of parhelia was seen at Gotha in May, 1824; the part of the sky in which the sun appeared, as well as the opposite quarter, was covered with small bright clouds. A circle of prismatic colours surrounded the luminary, a little out of this circle, but at the same height as the sun, two parhelia displayed all the prismatic colours with great brilliancy; a third, less bright, was observed in the circumference. A second arch, concentric with the first, but of double its radius, was beautifully tinted at the highest part, the lower being interrupted by the horizon. Two other arcs, and an inverted one, accompanied the former, also coloured, but having the tints in an inverted order: the whole presented the most interesting and beautiful appearance.

The late Mr. Fallows witnessed a singular kind of parhelia at the Cape of Good Hope: the moment the lower limb of the setting sun touched the sea-horizon, its image was repeated seven times, four on one, and three on the other side of the luminary. These mock-suns were smaller, and decreased outwardly in size. They continued visible till the sun sunk below the horizon; just before that, they disappeared successively, but instantaneously. This phenomenon is shown at the bottom of the engraving.

When the moon presents these singular appearances they are called Paraselene; in this case, the whole phenomenon is fainter, but in other respects differs in no essential particular from that we have described.

The above-mentioned phenomena are the result of *refraction* by transparent particles of vapour, but on some occasions, those constituting a cloud are so arranged as to *reflect* the sun, as from water; this appearance is called an Anthelion. Mr. Howard has noticed it on the body of a large cloud of the cumulus kind opposite the sun; generally the Anthelion only presents itself as a vague luminous spot on the broken surface of the cloud, but under very favourable circumstances it assumes a sharp circular outline, and is nearly as bright as the real luminary.

We shall describe the Rainbow and Aurora in a subsequent Supplement.

† This fact shows that refraction is one of the proximate causes, especially in producing inverted arcs, &c.

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